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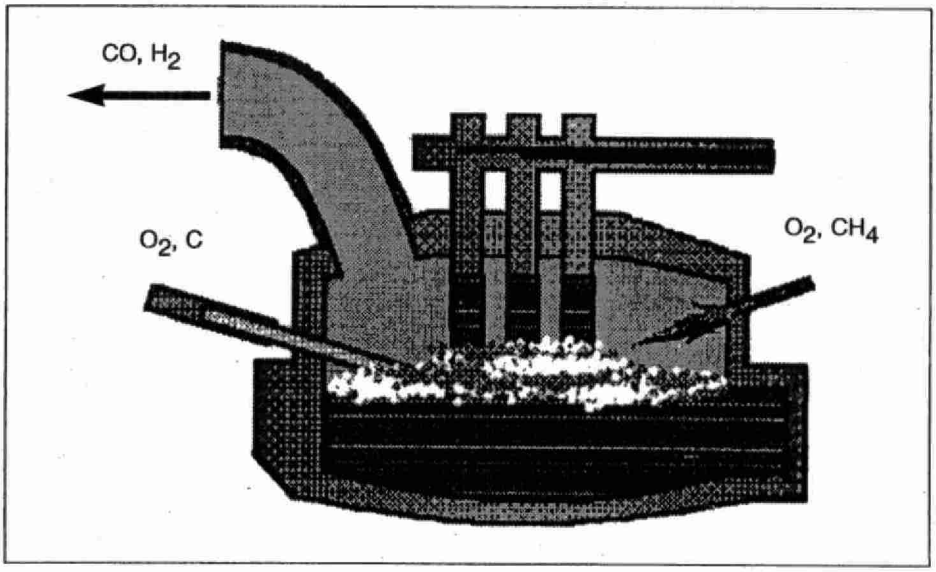
TECHNOLOGY STATUS REPORT

Electric Arc Furnace Fume Systems and Control Technologies



Ministry of the Environment

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TECHNOLOGY STATUS REPORT
Electric Arc Furnace Fume Systems and Control Technologies

November 1997

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LIST OF ACRONYMS

EAF	Electric Arc Furnace
ACFM	Actual Cubic Feet per Minute
DEC	Direct Evacuation Control
EFSOP	Expert Fume System Optimization Process
DRI	Direct Reduced Iron

1. INTRODUCTION

Electric Arc Furnaces have been used in North America to make steel since 1906. Although uncommon at first, EAF melt shops have since steadily increased their share of the steelmaking market as companies have developed their expertise and increased production. The share of the steel market produced by EAFs grew from 19 per cent in 1976 to 36 per cent in 1986, and should reach 50 per cent by the year 2000[1,2].

Systems to control emissions from steelmaking have always been needed and particularly so with the advent of more stringent environmental regulations in recent years.

However EAF fume systems have only lately been viewed as an opportunity to save energy and improve the steelmaking process. Steelmakers are now more aware of how an emission control system which is well designed and maintained can protect the environment and improve the productivity of their operations.

This report highlights the technological improvements in EAF operations which have resulted in modern fume control technologies and which are the basis for future developments.

2. THE HISTORY OF EAF DEVELOPMENTS[1,2]

The Heroult company in France introduced the EAF in 1899. The technology has since developed from being a slow process into a rapid melting machine that performs at a level which approaches that of the basic oxygen furnace.

In the 1950s EAFs were small and usually located in a back corner of the melt shop. Emissions were relatively low and were of little concern to the steelmaker. The emissions were simply collected by fume hoods which were located above the furnace.

However to ensure that the fume system operated properly, the associated duct work had to be telescoped or detached and cleaned during the steel pouring operation. This made the steelmaking process cumbersome. The solution was to eliminate the hoods and attach the duct work to the so-called fourth hole in the furnace roof. This represented the first form of a primary fume control system.

From 1965 to 1969 several primary EAF fume control systems were installed in the United States. Unfortunately the hot gases at the fourth hole caused considerable problems in the duct work. This problem with the original designs was later solved by using water-cooled ducts to reduce the temperature of the gases.

In the United Kingdom many gas collection systems were based on electrostatic precipitators that used conditioning towers to improve gas cleaning efficiency. Several facilities tried to use scrubber technology, but these were difficult to maintain and were deemed to be unreliable.

In order to improve the steelmaking process, oxygen was introduced into the furnace. This increased the amount of exhaust gases and dust and occasionally caused an explosion.

These problems prompted the British Iron and Steel Federation to study the problem of air pollution from EAFs. In April of 1963 their report on the "Safe Treatment of Waste Gases" recommended that waste gases should be burned in a combustion box under controlled conditions[5].

In response the British Steel Corporation (BSC) developed a combustion chamber for use in all of the company's EAF steel plants. The chamber was a refractory-lined cylinder which measured approximately 2.1 m in diameter and 3.4 m long. The combustion air was injected perpendicularly to the furnace off-gas flow through three radial tubes at the inlet to the combustion chamber. The after burners were located in two positions down stream from the injection of combustion air and were fuelled by natural gas or propane.

Many EAF fume systems were installed in the United States in the early 1970s. However little or no development work was done to establish optimal designs. Most systems were based on experience and by copying previous installations, and deficiencies were simply corrected as they became apparent.

One example of this approach was a fume control system based on direct evacuation which was installed by Laclede Steel in 1965[6]. By 1969 it was recognized that the equipment needed to be significantly modified to improve its fume collection capabilities. The plant had to construct a 1.1 million ACFM DEC/canopy system which cost more than $5 million.

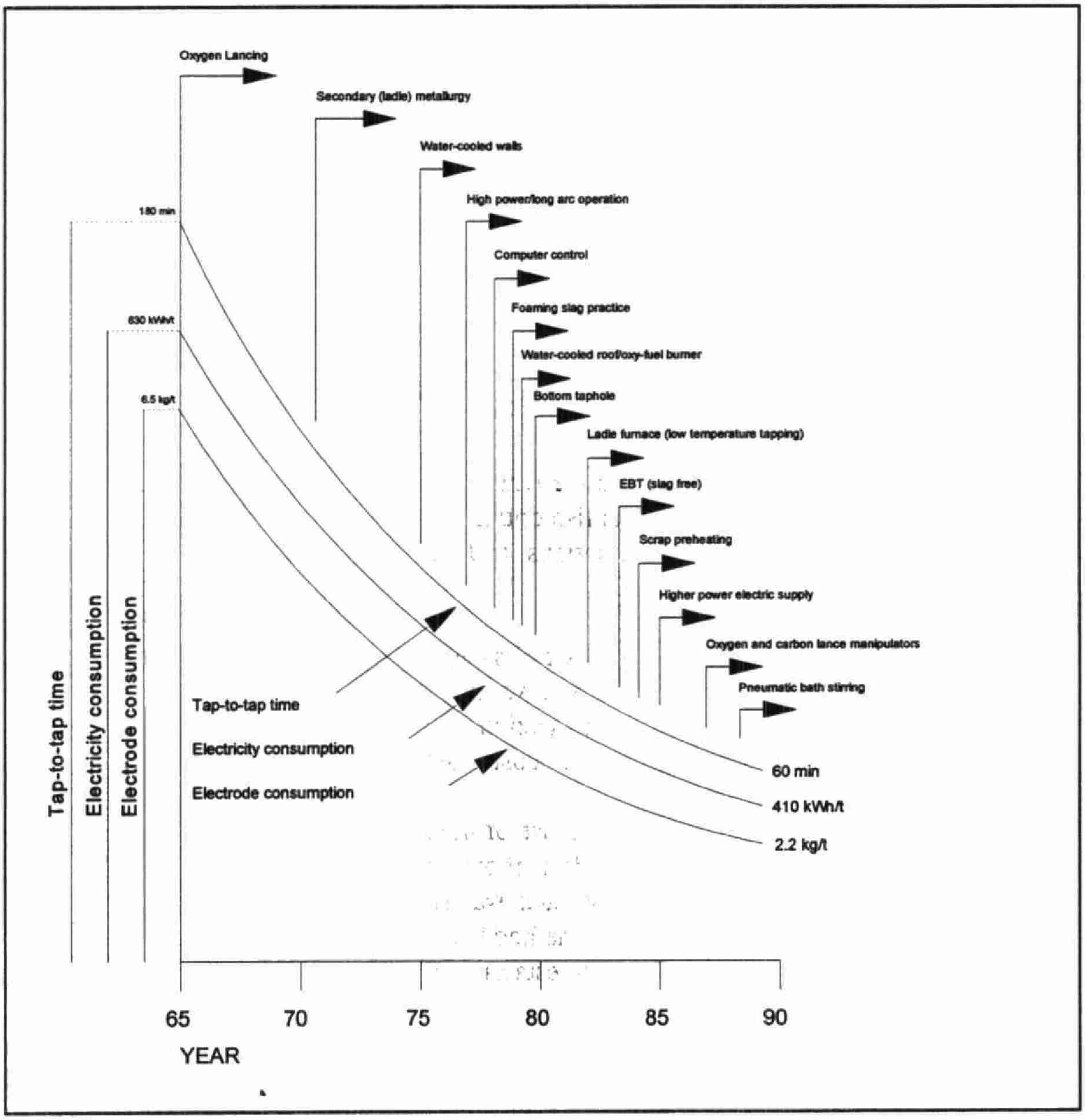
In the United Kingdom, most melt shops because of their different shop geometries and melting practices installed similar pilot hoods as those used in the United States. In 1971 a test program to measure plume density and flow rates was started at the melt shop of BSC in Templeborough. As a result of these tests, the hoods and off-takes were modified and a statistical analysis program was developed to establish optimum control for melt shops with many furnaces.

In 1976, Marchand[7] with BFI in Düsseldorf concentrated his efforts on improving the dust collection systems in the EAF melt shops in Germany. He evaluated different layouts and different roof off-take configurations in melt shops that used enclosed furnaces.

Substantial developments in fume control systems were made in the 1980s. These included furnace enclosures and the application of evaporative cooling to peak shaving for ultra-high-power furnaces. To improve heat transfer and reduce maintenance costs, new designs for water-cooled ducts were developed. New computer design programs also evolved to assist in the sizing of the DEC systems and canopy hoods.

These and other technical improvements have decreased tap-to-tap times and reduced electricity use and electrode consumption (Figure 1).

Figure 1 Influence of arc furnace technology on the main operating parameters of EAFs[4].



3. ELECTRIC ARC FURNACE OPERATION OVERVIEW

The four major steps in scrap based EAF steel production are:

- scrap handling and preparation;
- melting and refining;
- casting; and
- rolling.

The first step is the sorting and shredding of the scrap. The shredded scrap is then moved by rail or truck to the scrap bay in the melt shop building.

The melt shop houses the EAF. The scrap is charged into the furnace along with carbon, lime and other additives. The primary energy source for the furnace is electricity, but significant amounts of hydrocarbon gas and oxygen are also used. Once the scrap has been melted, the molten metal is tapped into large refractory lined mobile vessels which are known as ladles. The chemistry of the molten metal is adjusted to meet specifications at the ladle furnace.

The third step in the process is the caster where the liquid metal is poured from the ladle into a copper mold which is cooled by water. The solid metal which is produced is referred to as a billet, bloom, slab or round, depending on the size and shape of the cast product.

The final part of an EAF steel plant is the rolling mill. The cast product is shaped to meet customer specifications by passing it between rolls which revolve in opposite directions. The shaped steel is then sent to market.

4. EAF EMISSIONS[4]

All phases of operation at a steelmaking plant produce emissions. These emissions are categorized as primary if they are created during melting and refining, or as secondary if they occur during charging, tapping, slagging and other activities.

Iron oxide is the main component of emissions from the EAF. Iron oxide has a highly visible red to grey colour and a high percentage of particles which are less than 2 microns in diameter. Since the goal of every steel plant is to emit dust-free discharges to the atmosphere, highly efficient gas cleaning equipment is required.

Primary fume emissions can range from 7.5 to 20 kg of dust/tonne of hot metal tapped. The level of dust in the discharge depends on the cleanliness of the initial scrap, the amount of oxygen used, the quality of the lime, the power input level, the size of the fume system and the method of charge addition.

Secondary fume emissions can be as low as 0.5 kg or as much as 3.5 kg of dust generated per tonne of hot metal tapped. The amount of dust depends on the quality of the scrap, the number of back charges, the adequacy of the fume system, the duration of the tap, the type of furnace and the quality of the ladle additions.

Some estimates of particulate emission factors for a 100 per cent scrap metal shop and a DRI melt shop are provided below (Table 1). This information can be used to establish the level of fume control which is necessary to achieve specific rates of particulate emissions and meet requirements for opacity.

Table 1 Estimated particulate emission factors

Type of Emission	Operation	100 Per Cent Scrap Melt Shop		DRI Melt Shop	
		Particulate Emission Factor* (lb/ton of hot metal)	% Total	Particulate Emission Factor* (lb/ton of hot metal)	% Total
Primary	Melting/refining	28.0	93.00	28.0	95.60
Secondary	Charging	0.8	2.75	0.1	0.33
	Tapping	1.0	3.50	1.0	3.40
	Leakage around electrodes	0.2	0.75	0.2	0.67
	Total	**30.0**	**100**	**29.3**	**100**

*Factors estimated by Goodfellow (1985)[9].

5. EAF EMISSION CAPTURE TECHNOLOGY[1,3]

Since the EAF was invented, numerous technologies have been developed to capture the fumes which are generated by the steelmaking process. As the EAF process has improved so has the need to improve these techniques for fume capture.

Early fume control systems were based on full hoods which were designed to capture all the emissions from the steelmaking process. Over time and with improvements in the steelmaking process, improved emission controls were needed. In 1981 the Environmental Protection Agency published an article on "Electric Arc Furnaces and Argon-Oxygen Decarburization Vessels in Steel Plants - Background Information for Promulgated Standards" which described some of the technical features of the different types of fume collection systems.

At the Iron and Steel Society 1975 Electric Furnace Conference, Bruce Steiner of the American Iron and Steel Institute described seven different combinations of possible fume systems that can be used to control primary and secondary emissions. Most are based on the fourth hole DEC or roof canopy systems. A brief description of the more common systems follows.

The fourth hole DEC system works by evacuating the furnace through the associated duct work which feeds the gas cleaning equipment. The emission gases are cooled by diluting them with air and using water cooled ducts. The capacity of a DEC system is typically 1,000 Nm^3/hour per tonne of furnace capacity.

However fourth hole DEC systems do not always operate as designed. For example, changes in furnace pressure due to bath reactions and oxygen feeding occasionally cause fumes to escape through doors, ports, roof-sidewall joints and electrode openings, bypassing the DEC system. The DEC system also does not collect the fumes which are generated by the process when the EAF roof is open during charging and tapping. These fumes escape to the roof of the building and pose an environmental hazard if they are not collected.

Many other EAF operations utilize a deep rectangular canopy hood over the furnace to capture the fumes generated during charging, tapping, melting and refining. The canopy hood must be located so that the movements of any overhead cranes and other operations in the melt shop are not impeded.

The effectiveness of canopy hoods is greatly increased if they have a large storage capacity. This greatly reduces the risk of fugitive emissions being released into the atmosphere. The drawback of canopy hoods is that they cost more to install and operate. These types of systems typically have capacities of 340,000 to 850,000 Nm^3/hour per furnace.

Both the fourth hole DEC and roof canopy systems have certain disadvantages. However the two systems are substantially more effective when they are combined. Dampers and adequate controls are also necessary to ensure proper collection of fumes under different furnace operating conditions.

Total shop evacuation is another available system. In this process the entire building is sealed and the fumes from the EAF are collected and filtered before the exhaust air is released to the atmosphere. A disadvantage of a total shop evacuation system is the extremely high capital, operating and maintenance costs. This type of evacuation system also must have enough capacity to exhaust all EAF fumes. Otherwise working conditions for the plant employees will deteriorate. The capacity of this type of system usually ranges from 2 to 3.4 million Nm^3/hour.

Furnace enclosures are a recent innovation in fume system design. Furnace enclosures seal in all the fumes which are generated by the EAF and then exhaust the fumes through filters. This system typically needs less capacity than other fume control systems and this lowers the capital and operating costs. The DEC/canopy system for example requires 2.5 times more capacity than the furnace enclosure and the shop evacuation system requires 8 times more capacity. A further advantage of the furnace enclosure is that it substantially reduces noise emissions from an EAF.

6. EAF EMISSION CONTROL TECHNOLOGY[4,8,9]

Three types of technologies are currently used for fume control at EAF plants; high-energy scrubbers, electrostatic precipitators and fabric filters.

Scrubbers were originally used in small EAFs and they worked reasonably well. However as the furnaces got bigger it was necessary to move to high-energy scrubbers. Electrostatic precipitators were installed in a few plants but they were expensive and inefficient. Fabric filters are now preferred in over 95 per cent of the plants in North America, Europe and Japan.

7. EAF EMISSION CONTROL DEVELOPMENTS[10]

About 95 per cent of the EAF market use DEC/canopy hood systems. Traditionally such systems are designed to accommodate the peak heat load and volume requirements based on the most intense period of furnace practice. The system operates at this peak level for the entire heating period and this leads to a high heat loss from the furnace.

Systems used today are also usually operating at capacities above that for which they were designed. Hence, there are numerous plants with inadequate DEC/canopy hood structures.

8. INNOVATIONS IN ELECTRIC ARC FURNACE OPERATIONS

Steelmakers are constantly striving to improve the steelmaking process. Recently several processes and technologies have emerged that enable steelmakers to increase their production rates and also to minimize the effect of the steelmaking process on the environment.

8.1 Scrap Preheating

Substantial electric energy can be saved by preheating scrap prior to charging. This techniques was first practised by the Japanese and the European steelmakers in the 1970s and the process has recently been adopted by some American steelmakers looking to improve their productivity and reduce their energy use. One major drawback of the preheating of scrap is the environmental problems which are associated with the transport of the preheated scrap to the EAF. The preheated scrap may still contain other semi-burned materials such as plastics which can be environmentally hazardous. Many of the systems in Europe have stopped using preheated scrap due to this concern, but technologies and processes have been developed to address the problem.

Steelmakers that use preheating of scrap report savings between 30 and 70 kWh/tonne of liquid steel[12]. Charging heated scrap to the furnace reduces the total heating time and reduces the tap to tap times. This lowers power consumption and extends the life of the electrode. Other

benefits of preheated scrap are reduced shop noise and emissions, and the ability to charge oily scrap.

Roughly 75 per cent of the total energy used in the EAF is to heat scrap. The balance of the energy goes into melting the solid scrap (approximately 20 per cent) and superheating the liquid to tapping temperature (5 per cent)[13]. Typically electrical energy provides the majority of the energy. However over the last 30 years the EAF has become multi-fuelled to improve heating efficiency, with the supplemental energy from oxygen injection and oxy-fuel burners. The heat content of the preheated scrap depends on its temperature (Table 2), and this heat reduces the energy needed from other sources.

Table 2 Heat content in preheated steel scrap[13]

Scrap Temperature	Heat Content (kWh/t)
300°F (150°C)	22
500°F (260°C)	40
700°F (370°C)	57
1000°F (540°C)	81

Scrap preheating operations can be continuous or batch processes and can use external heating sources, waste gas heating, or a combination of both.

8.1.1 Batch Preheaters

Typical batch preheaters are refractory lined buckets where the scrap is heated before it is charged to the furnace.

External Heating Sources

In this process the scrap is preheated by an external source such as a fuel-fired burner. It is important to closely monitor the results of this process. The steelmaker needs to be sure that the savings from increased production and reduced consumption of power by the furnace offset the cost of the external heating. Otherwise the process is not economically feasible. This method has been successfully implemented at Bethlehem Steel since 1971, Harrison Steel Castings and recently at Washington Steel[14].

Waste Gas Heating

The heat from waste gas, which would normally be lost to the environment, can be used to preheat the scrap. The installation at Badische Stahlwerke in Germany uses this technique. The waste gas heat from the furnace is collected through the fourth holeof the furnace and the

heat is forced through the scrap using water-cooled ducts and fans. Other locations which have successfully used waste gas heating are DDS in Denmark, which uses the Fuch's shaft furnace, Knoxville Iron Co., and Timken in Canton, Ohio[14].

8.1.2 Continuous Preheaters

In continuous preheating systems, the scrap travels on a conveyor into the preheater. The conveyor may be vibrating, rotating kiln or gravity feed type.

Waste Gas Heating
EMPCO has developed the Verticon process[14] for continuous pre-heating of scrap using waste gases. In this technique the charged scrap is held in a heated vessel which is located above the EAF furnace. The full heat charge for the furnace is contained in the vessel and is continuously charged after preheating. The off-gases from the furnace are collected and directed into the vessel for further incineration and preheating of scrap.

Combination Waste & External Heating
The BBC/Brusa process used in Italy uses waste gases from the furnace and heat from burning supplemental fuel to preheat the scrap[14]. The charged scrap is fed through an inclined revolving kiln which is heated by the waste gases from the furnace. The scrap is also further heated by gas-fired burners before it leaves the kiln.

The Consteel process developed by Intersteel Technology Inc. in the USA is another type of continuous process that uses a covered conveyor type preheater. The system is made up of a charging conveyor for scrap, a feeding system to introduce carbon and fluxes, and a preheater. The preheated scrap is taken from the scrap preheater to the EAF via a connecting car.

8.2 Post-Combustion Technologies

Underbath oxygen lancing is the standard practice used in electric steelmaking since the early 1960s. During lancing the carbon is partially oxidized to CO which is used to heat scrap in the EAF. Unfortunately a large amount of the chemical energy of this process is lost as the furnace gases are exhausted to the fume system.

The addition of oxygen during the post-combustion process to convert CO into CO_2 allows much of this chemical energy to be recovered. Post-combustion is the most cost effective means available to supply energy to the furnace and to increase its productivity. The amount of oxygen used in EAF operations has steadily risen from 2 to 17.5 Nm^3/ton of steel over the last 20 years[15].

Praxair has used their expertise and experience to develop equipment and practices for efficient post-combustion in the EAF at Nucor's melt shop in Plymouth, Utah. The tests at Nucor

involved three components: off-gas analysis, post-combustion with burners, and post-combustion with PC-lances[16].

L'Air Liquid has also had some success in developing and implementing their ALARC PC process with allows for the efficient recovery of chemical energy in the off-gases. The system was installed at Vallourec St. Saulve Steelworks with the objective to increase productivity. The installation has reported a decrease in tap-to-tap time of 4 minutes and a reduction in electricity consumption of 43 kWh/tonne[17].

8.3 The Expert Fume System Optimization Process (EFSOP)[10]

Goodfellow Consultants Inc. of Mississauga, Ontario, has developed a technology to control and optimize the operation of the EAF fume system. The EFSOP system continuously analyses the emissions, measures flow and temperature and monitors real-time process data in order to adjust fume system set points and operation on a minute-by-minute basis.

The EFSOP system provides on-line measurements in real-time of what is occurring as the furnace emissions are exhausted. An added advantage is that the system can be used to control post-combustion systems. This optimizes furnace combustion, increases production and saves energy. Steelmakers have reported energy savings of 20 kWh/ton of steel and tap-to-tap time reductions of 2 to 3 minutes with EFSOP.

Where plants are operating with inadequate DEC/canopy hood systems, EFSOP can quantify the amount of heat being released to the DEC system and determine what shortfalls exist in the system. Specific upgrades can then be identified.

The EFSOP system analyses the furnace off-gas just before the combustion gap to quantify the amount of carbon monoxide (CO) in the off-gas. The CO results from the incomplete combustion of oxygen and fuel in the furnace shell. Some furnace practices and scrap mixes also cause high levels of hydrogen (H_2) in the off-gas streams. Together, these combustible gases can make up over 30 per cent of the furnace off-gas and they represent a tremendous loss of energy.

This loss and the high temperature of the off-gas can mean a waste of more than 2,000,000 BTU/min (over 500 kWh/min) at peak points in the melts. This represents over 50 per cent of the electrical energy used by the furnace. As well as CO and H_2, oxygen and carbon dioxide are measured in the gas sample. The flow and temperature of the off-gas stream and process parameters from the furnace operating system also are monitored to give a complete real-time picture of the inputs and outputs of the process.

The EFSOP system allows the steelmaker to tune the operation of the DEC system to match the actual requirements of the process. The continuous fume analysis of the furnace off-gas allows the steelmaker to conduct controlled post-combustion and to capture some of the energy

that is being lost in the off-gas in the furnace, before it escapes into the DEC system.

Once profiles of the off-gas have been established, alternative practices to optimize the operation of the furnace can be evaluated. This makes it possible to set operating parameters for the fume system which match the existing and anticipated heat load profiles. By monitoring process data from existing furnace control systems, these set points can be adjusted in real-time to match the actual furnace practice and to accommodate process upsets.

The EFSOP technology has been used at a major Canadian steelmaker for several months and the data has yielded some valuable information such as:

- the CO and H_2 levels in the off-gas are significant for long periods of the heat. Maximum CO levels can exceed 25 per cent while maximum H_2 levels can be more than 20 per cent;
- measurements are highly variable which indicates that the process is complex and that many factors interact to affect the off-gas chemistry; and
- the furnace loses significant amounts of heat while the system is idle.

A post-combustion strategy is presently being evaluated and a control strategy for the DEC is also being developed at this facility. It is conservatively estimated that such a control strategy could save more than $1,000,000 each year. Note that steelmaking practices differ between EAF facilities and the control strategy for each plant must be individually developed.

9. THE ONTARIO EAF MARKET[11]

Steel is produced in Ontario at integrated mills that use the Blast Furnace-Basic Oxygen Furnace process and in mini-mills that use Electric Arc Furnaces. There are currently 7 EAF mini-mills operating in the province; Atlas Specialty Steels, Courtice Steel Inc., Co-Steel Lasco, Dominion Castings Ltd., Port Hope Foundry, Ivaco Rolling Mills Ltd. Partnership, and Slater Industries Inc. In addition to these, Dofasco which is an integrated plant has also recently installed an Electric Furnace facility. Each mini-mill operation is outlined in Table 3.

The EAF melt shops in Ontario all operate a DEC and/or canopy hood type of system. The fume systems for these plants were all designed based on original furnace practice intensities.

Steelmakers in Ontario are increasing their production through improved technologies such as oxy-fuel burners, oxygen lances, foamy slag practice, carbon injection and the addition of DRI and iron carbide. These improvements to the EAF have significantly increased the intensity of their EAF operations. For example the tap to tap times have decreased from 180 minutes in 1965 to less than 60 minutes in 1990[1]. This has placed considerable stress on fume systems which have not substantially changed over the years.

Table 3 Electric Arc Furnace operation in Ontario[11]

Company /Location	# of Furnaces	Startup year	Furnace Manufacturer	Tap-to-Tap (hrs)	Heat size (short tons)	Oxy-Fuel Burners?	Max. cap. of transformer (KVA)	Electrode diam. (in)	Power consumption (kWh/t)	Collection system	Steel produced	Total EAF cap. (short tons/yr) (1,000's)
Atlas Specialty Steels (Welland)	1	1988	Empco	2	70	N	50,000	20	470	Baghouse	Alloy, stainless, tool	200
	1	1976	Whiting	3	70	N	30,000	20	490	Baghouse	Alloy, stainless, tool	120
Courtice Steel Inc. (Cambridge)	1	1988	Empco	1	42	N	30,000	18	500	Baghouse	Carbon, merchant bar	250
Co-Steel Lasco (Whitby)	1	1981	Empco[EBT]	N/A	130	Y	93,500	24	N/A	Baghouse	Carbon	800
Dominion Castings Ltd. (Hamilton)	1(A)	1917	Volta	2.33	11.5	N	3,500	10	480	Baghouse	Carbon, low alloy	24
	1(B)	1917	Volta	2.25	11.5	N	7,500	10	480	Baghouse	Carbon, low alloy	24
	1(F)	1942	Lectromelt	1.75	3	N	1,500	7	530	Baghouse	Carbon, low alloy	10
	n/a	1996	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	25
Port Hope Foundry (Port Hope)	1	1977	Lectromelt	1.5	6	N	3,400	8	520	Baghouse	Low alloy, stainless	3.8
Ivaco Rolling Mills Ltd. Partnership (L'Original)	1	1976	Salem	1.3	73	Y	45,000	18	400	Baghouse	Plain carbon, low alloy	440
Slater Industries Inc. (Hamilton)	1	1968	American Bridge	1.25	73	Y	40,000	18	420	Wheelabrator and American air filter	Alloy, carbon	400

EBT = eccentric bottom tapping

10. BARRIERS TO TECHNOLOGY

EAF steelmaking operations continue to face more stringent regulations on emissions from the melt shop and for contaminant levels in the workplace. For example the new particulate regulation for the EAF requires that emissions from the melt shop are less than 6 per cent opacity[2]. This would mean that the melt shop can never have visible emissions. The primary and secondary fume collection system at an EAF facility will need to perform much better than previously to comply with these regulations.

Other new regulations may reduce the acceptable levels in the workplace of metals such as lead and cadmium. Future designs of cost-effective fume control and ventilation systems for steel plants must account for these stricter requirements.

11. EMERGING TRENDS[3,4]

The main issues that will dominate future developments with EAF operations are the availability of capital, productivity, energy efficiency and environmental concerns. Successful steelmakers will have to use the best available technologies and methods to integrate gains in productivity with improvements in energy efficiency and compliance with environmental regulations.

The problem for many steelmakers is that they cannot afford to abandon their existing equipment or facilities. They must add and adapt improvements in technology to their existing EAFs. However it is important to ensure that the proper engineering is performed in order to determine the impacts on the overall operation. To increasing productivity without properly considering the impact on the fume control operations often results in existing fume systems being overloaded.

Emerging technologies will focus on meeting the following objectives:

- adoption of new scientific methods for the design of EAFs; the design of fume systems will be integrated with the furnace steelmaking practice and will no longer be based on empirical equations and rule of thumb practices.

- incorporation of continuous fume analysis into melt shop practice; the trend will be to equip all fume systems with analyzers that will characterize the flow and composition of the off-gas.

- limiting the amount of dust produced; more stringent environmental regulations mean that dust particles must be more effectively captured.

- moving towards the implementation of enclosed EAFs; the advantages in noise attenuation, higher productivity levels and reduced air pollution may encourage steel mills to adopt furnace enclosures.

- installing expert fume control systems; expert systems can be used on-line to operate EAF fume systems to optimize performance and improve the overall operation of the EAF.

12. SUMMARY

Electric Arc Furnace fume systems represent an opportunity to save energy and improve the steelmaking process. An emission control system which is well designed and maintained can protect the environment and improve the productivity of a steelmaking operation. Some of these opportunities and advances in technology which are discussed in this report include:

- improvements in steelmaking practices have caused fume systems to become overloaded and the majority of fume systems are operating at a level beyond that for which they were designed. The development of technologies for analysis and control means that the fume system can now be operated to closely match the operation of the EAF, which minimizes the use of the fume system and conserves energy.

- expert fume analysis systems will increasingly be used to evaluate the fume system operations and the EAF practices at steel mills.

- computer analysis systems and computer modelling systems will enable existing and new EAF plants to modify current and design new fume systems that will meet the increased heat load profiles at EAF plants while saving energy.

- expert fume systems will allow the steelmaker to more closely control post-combustion activities.

- improvements in productivity, energy use and emissions to the environment may encourage steel mills to utilize enclosed EAFs.

13. REFERENCES

1. J.J. Bosley, Techno-Economic Assessment of Electric Steelmaking Through the year 2000. EPRI Centre for Metal Production, Research Project 2787-2, October 1987.

2. H.D. Goodfellow, Application of Variable Speed Fans to Electric Arc Furnace Fume Systems, Air Pollution Control Specialty Conference, October 9-11, 1990.

3. Research and Development Department, Stelco Inc., Present and Future Use of Energy in the Canadian Steel Industry, Efficiency and Alternative Energy Technology Branch, CANMET, Energy, Mines and Resources Canada, Ottawa, Ontario, March 1993.

4. H.D. Goodfellow, Fume Control for EAFs - Past, Present and Future, 12th Process Technology Conference, Part III: Environmental Concerns in EAF Steelmaking, Washington DC., November 1993.

5. Air Pollution from Electric Arc Furnaces: Safe Treatment of Gases, British Iron and Steel Federation, April 1963.

6. R.A. Garvey, Design and Installation of Fume Control System During Operations, Electric Furnace Proceedings, ISS, Vol. 33, Houston, TX, 1975, pp.26-29.

7. D. Marchand, Possible Improvements to Dust Collection in Electric Steelplants and Summary of All Planned and Existing Collection Systems in the Federal Republic of Germany, Ironmaking and Steelmaking, 1976, pp.221-229.

8. R.W. Manten, P.G.A. Brand, A Practical Primer on Design of EAF Emission Control Systems. Hatch Associates, Mississauga, 1994.

9. Elsevier Science, H.D. Goodfellow, Advanced Design of Ventilation Systems for Contaminant Control, Amsterdam, 1985, pp. 416-419.

10. H.D. Goodfellow, The Expert Fume System Optimization Process, News Release, Mississauga, Ontario, Nov. 1995.

11. Electric Arc Furnace Roundup - Canada, Iron and Steelmaker, Annual Report, May 1995.

12. Aristide Jean et al, The 90's Electric Arc Furnace Steelmaking Route: The Leap Forward, Proceedings of the Sixth International Iron and Steel Congress, Nogoya, 1990, pp. 180-189.

13. C. Baukal, M. Lanyi, D. Winchester, Scrap Preheating with a Submerged Oxygen-Fuel Burner, ISS Spring Conference, Detroit, MI, 1990.

14. Donald E. Klessen, Overview of Scrap Preheating, Centre for Materials Research, 1991 Electric Furnace Conference Proceedings, pp. 67-69.

15. The Electric Arc Furnace - 1990, International Iron and Steel Institute, Belgium, 1990.

16. Pravin Mathur, Giffin Daughtridge, Oxygen Injection for Effective Post-Combustion in the EAF, 51st Electric Furnace Conference Proceedings, Nov. 7-10, 1993.

17. Industrial Practice of a New Injection Process of L'Air Liquide for Post-Combustion at Vallourec Saint-Sauve.

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1997

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